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Recruitment Variability of Cod Stocks

by

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In order to characterize the variability of cod recruitment, time-series for all stocks in the North Atlantic will be examined. I will summarize (a) the variability in recruitment, (b) the distributional characteristics of recruitment variability, (c) density-dependent mortality within and between year classes, and (d) the role of environmental factors controlling recruitment.

This paper summarizes work on recruitment variability of Atlantic Cod with coworkers: Keith Thompson, Ken Drinkwater, Pierre Pepin, Gordon Mertz, Andy Rosenberg, Noel Cadigan, and Wade Blanchard.

COD SYMPOSIUM, SEPTEMBER 1991

DATA

Much of the data used in the analysis is described in

"Summary of North Atlantic fish Recruitment 1942-1987" by R. A. Myers, W. Blanchard, and K. R. Thompson
Can. Tech. Report of Fisheries and Aquatic Sciences No. 1743.

Plots of Cod Recruitment data.

Recruitment Variability in Cod Compared to Other Species

Variability is described as the standard deviation of log (base 10) recruitment. Recruitment variability in cod is greater than flatfish, which have low recruitment variability, but is smaller than other species such as redfish that live on the continental slope (Fig. 4).

Recruitment Variability is greater at the Edges of the Range

Recruitment variability in cod is greater at the northern and southern limits of the species range on both sides of the Atlantic (Fig. 5).

Variability is described as the standard deviation of log (base 10) recruitment. The result remains valid if alternative measures of variability are used.

These results are in press in J. of Animal Ecology.

WHAT IS THE DISTRIBUTIONAL SHAPE OF COD RECRUITMENT?

The recruitment series were fit to gamma and log-normal models using maximum likelihood methods. There is little difference in the fits. There are only two stocks where the log-likelihood is different by more than two, the difference that would be approximately significant in a nested model. Therefore, any model that uses a theoretical distribution of recruitment should be robust to these two alternative distributions.

RECRUITMENT IS MORE VARIABLE AT YOUNGER FOR YOUNGER JUVENILES. THIS PATTERN IS CONSISTENT WITH STRONG DENSITY DEPENDENT MORTALITY WITHIN AN AGE CLASS.

By examining several research surveys simultaneously for the same stock it is possible to separate measurement error from true variation in stock size. For some stocks, e.g. cod in the Irish Sea, this pattern is fairly obvious without any analysis. For others, the pattern can be seen using maximum likelihood methods that fit the observed covariance matrix of log-transformed recruitment series to a theoretical matrix in which recruitment variability, the linear relationship between the recruitment estimates, and variance of measurement error.

RECRUITMENT APPEARS TO BE NEGATIVELY CORRELATED BETWEEN ADJACENT COHORTS. THIS PATTERN IS CONSISTENT WITH DENSITY-DEPENDENT MORTALITY BETWEEN ADJACENT YEAR CLASSES.

If there are several research surveys of the same stock, it is possible to estimate the correlation between adjacent year classes that would be present if there were no measurement error. For all stocks studied so far this correlation is negative! The positive autocorrelation seen in VPA estimates of recruitment for some cod stocks is probably due to errors in estimating catch at age.

AUTOCORRELATION IN VPA ESTIMATES OF RECRUITMENT IS GREATER IN STOCKS WITH LARGE AGE OF RECRUITMENT OF THE FISHERY.

Joint work with Keith Thompson, Dalhousie, has shown that positive autocorrelation in recruitment is only important in stocks with a large age of recruitment to the fishery. This is probably caused by errors in estimating catch at age. note also that there is a negative correlation in stocks with small age of recruitment to the fishery.

This is to be published by Keith Thompson, W. Blanchard and R. A. Myers.

ENVIRONMENTAL FACTORS AND RECRUITMENT

Warm Core Rings Appear to Reduce Recruitment in a manner consistent with the advective loss of cod eggs and larvae.

Myers, R. A. and K. F. Drinkwater. 1989. The influence of Gulf Stream warm core rings on recruitment of fish in the northwest Atlantic. J. of Mar. Res. 47:635-656.

Ekman Transport does not appear to be an important source of advective loss of cod eggs and larvae.

Myers, R. A. and K. F. Drinkwater. 1990. Off-shelf Ekman transport and larval fish survival in the northwest Atlantic. Biol. Ocean. 6:45-64.

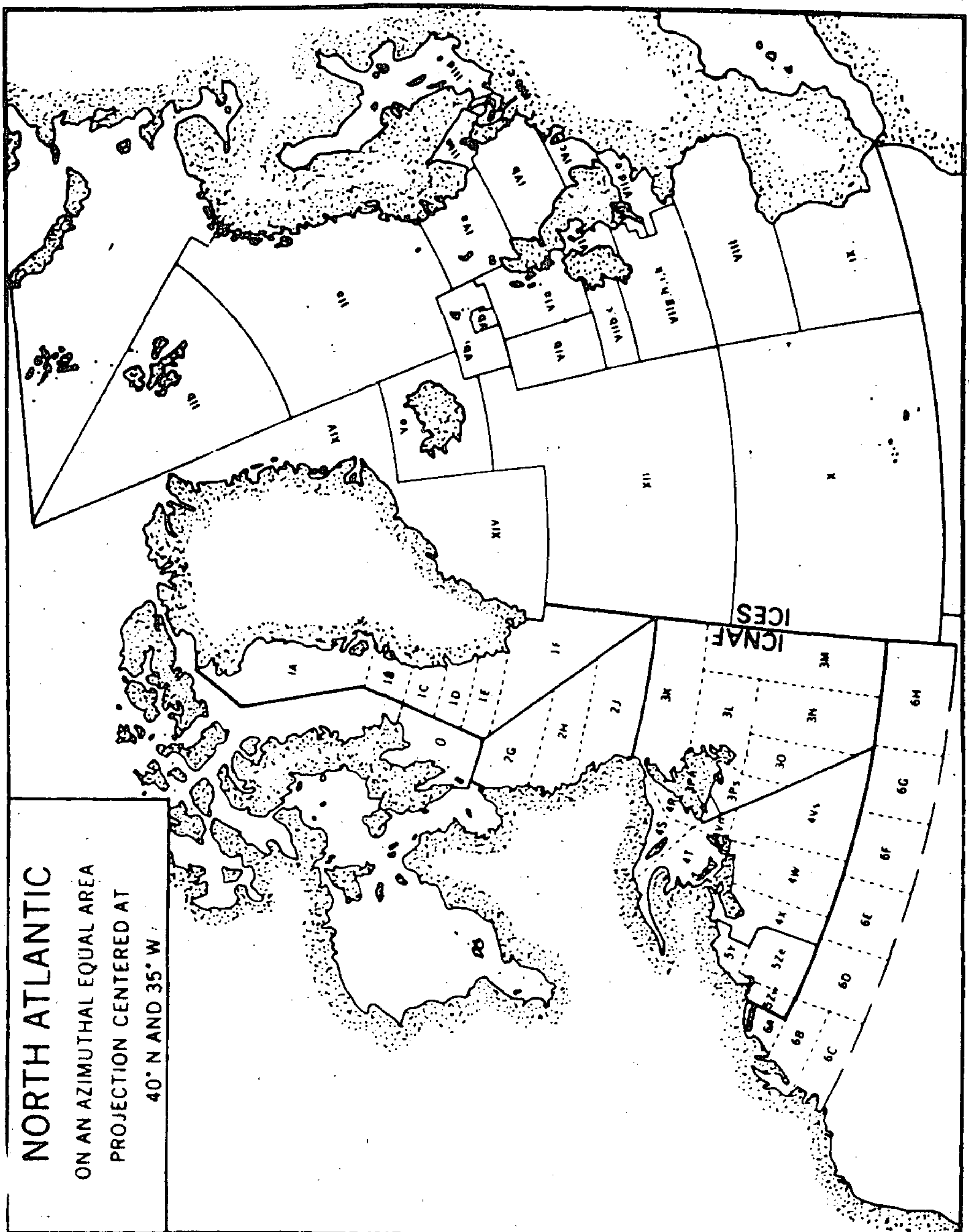

Fig. 1. The locations of the cod populations in the north Atlantic.

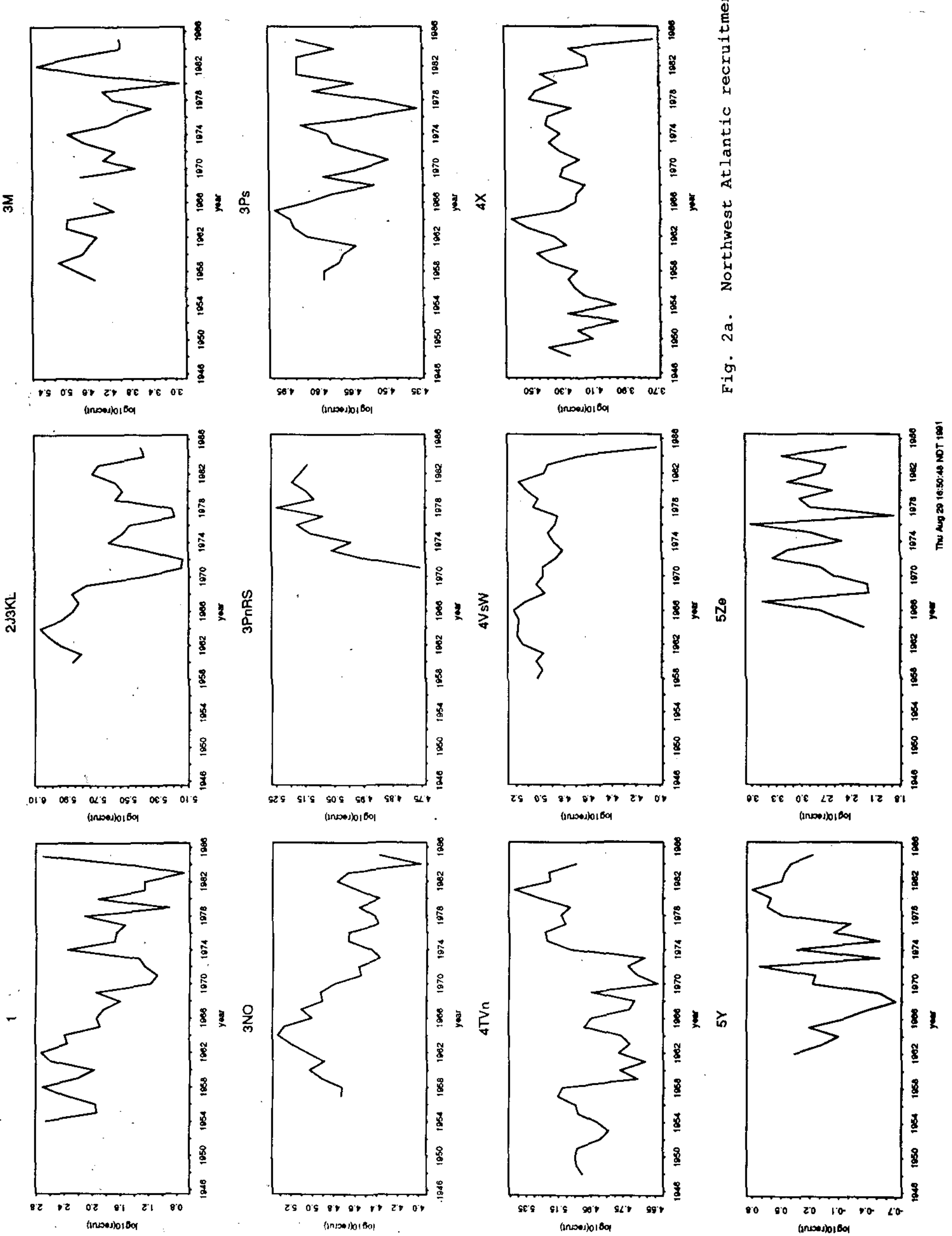

Fig. 2a. Northwest Atlantic recruitment.

Fig. 2. Plots of log (base 10) recruitment, note scale is different on all plots.

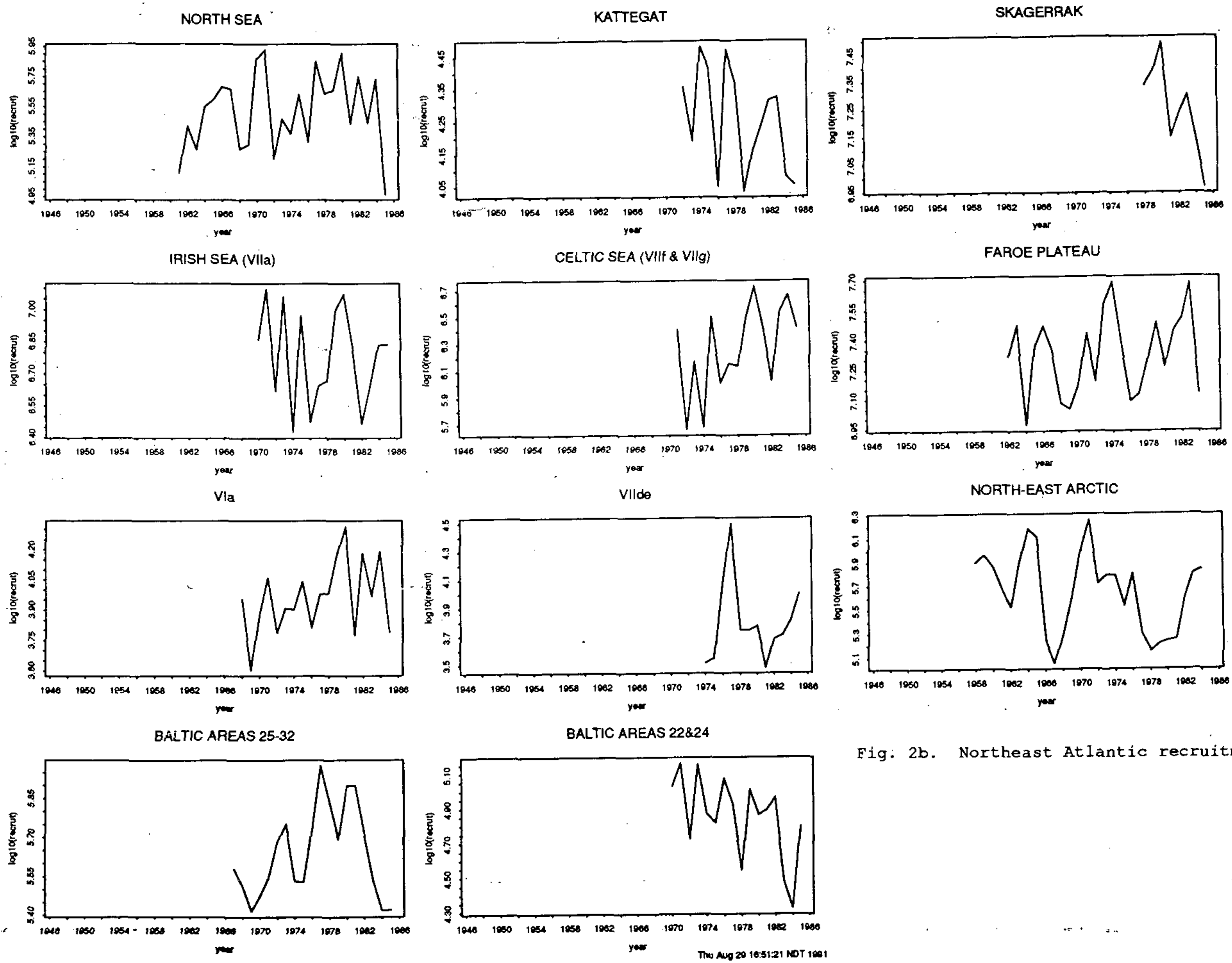

Fig. 2b. Northeast Atlantic recruitment.

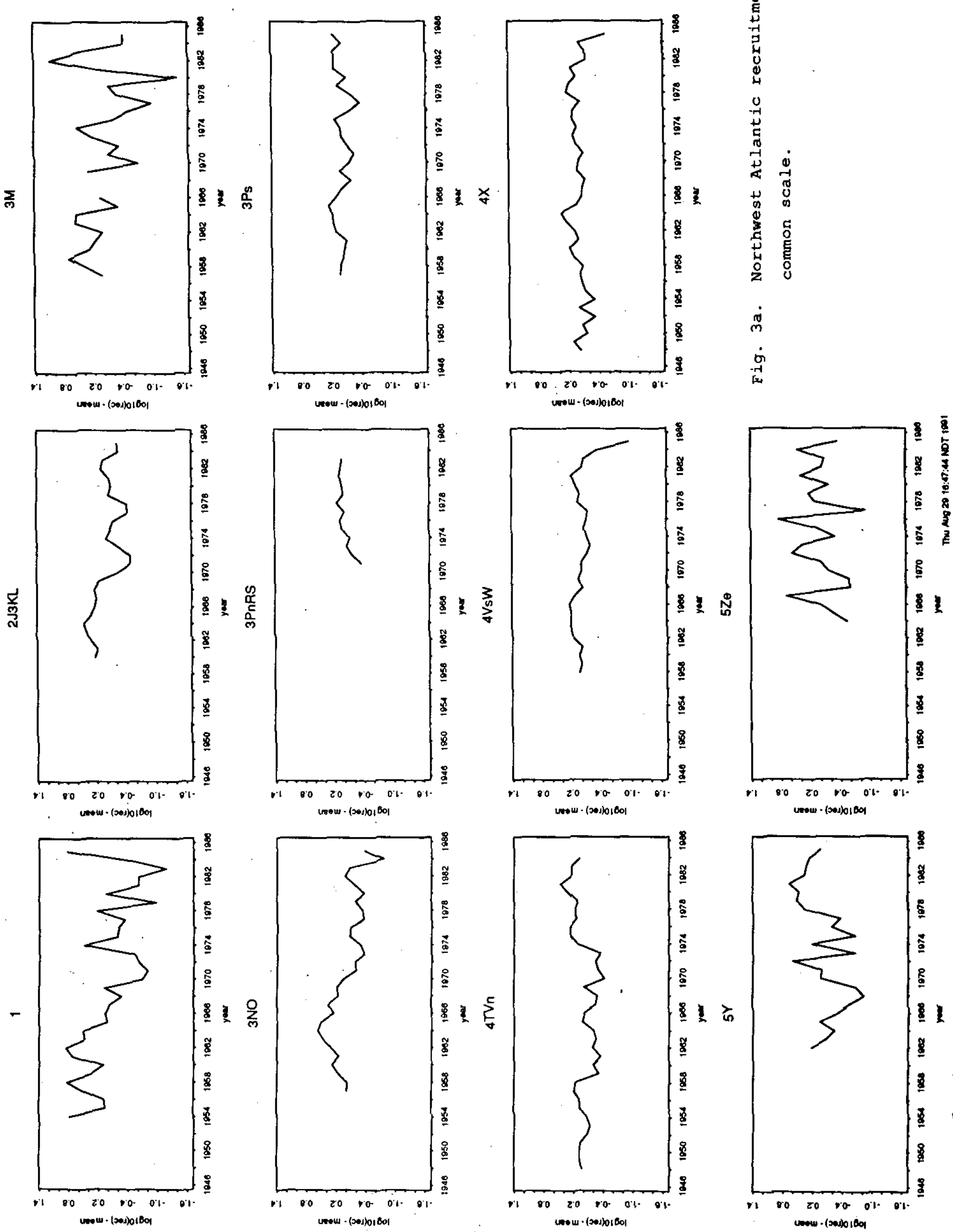

Fig. 3a. Northwest Atlantic recruitment, common scale.

Fig. 3. Plots of log (base 10) recruitment, mean removed and common scale used for all plots. This plot shows differences in recruitment variability.

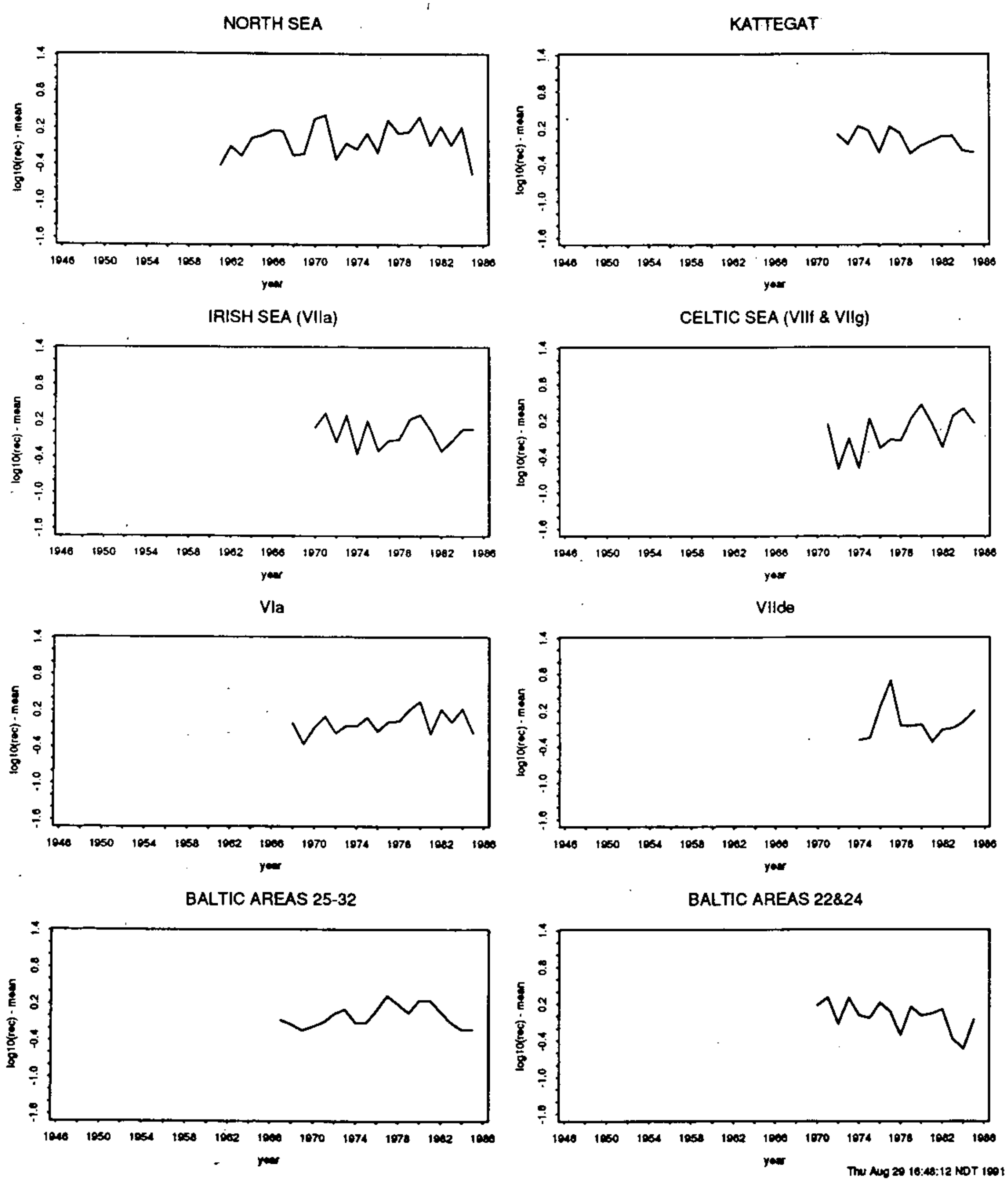

Fig. 3b. Northeast Atlantic recruitment, common scale.

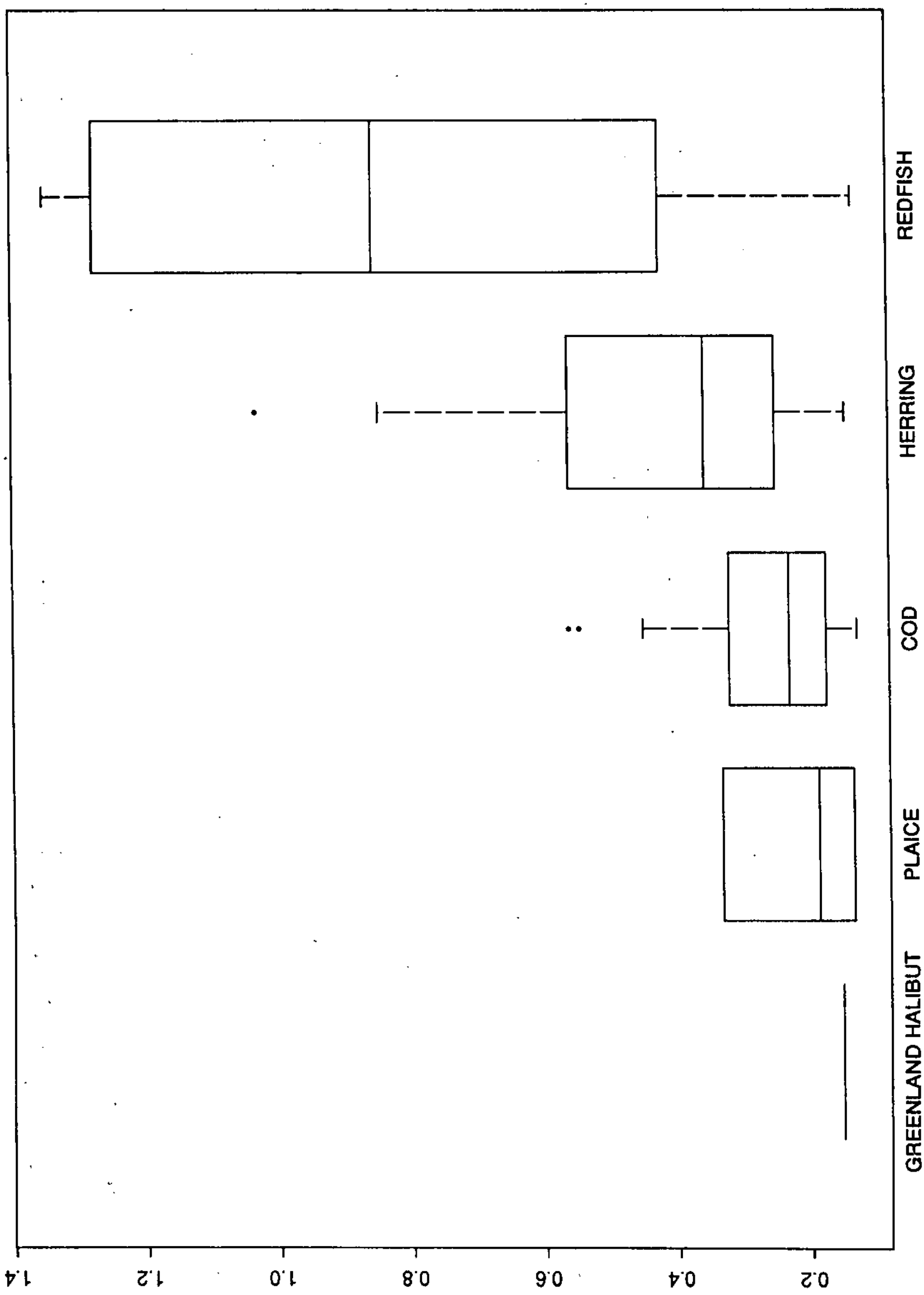

Fig. 4. Box plot of the standard deviation of log (base 10) recruitment.

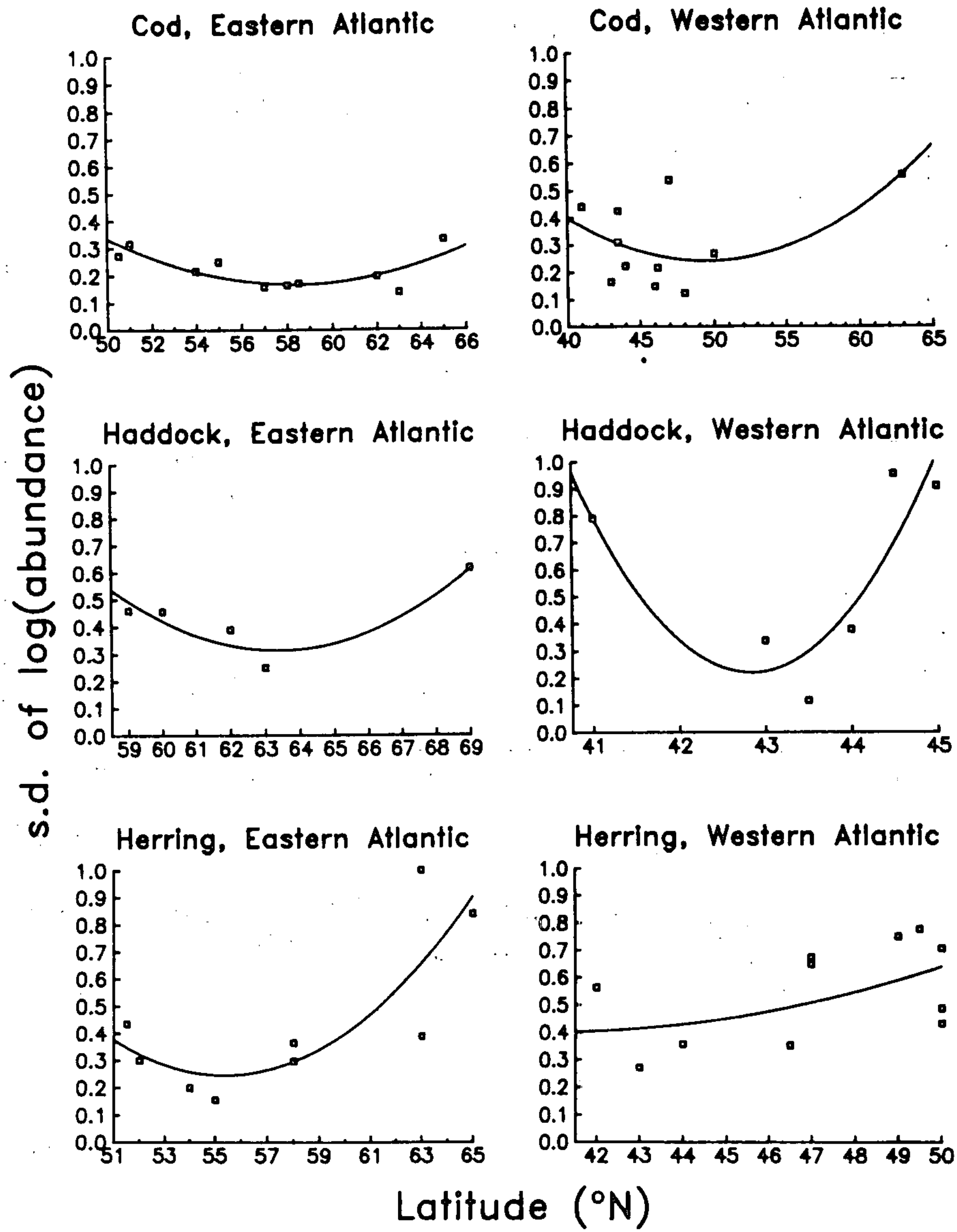

Fig. 5. The standard deviation of log (base 10) recruitment vs. latitude of spawning.

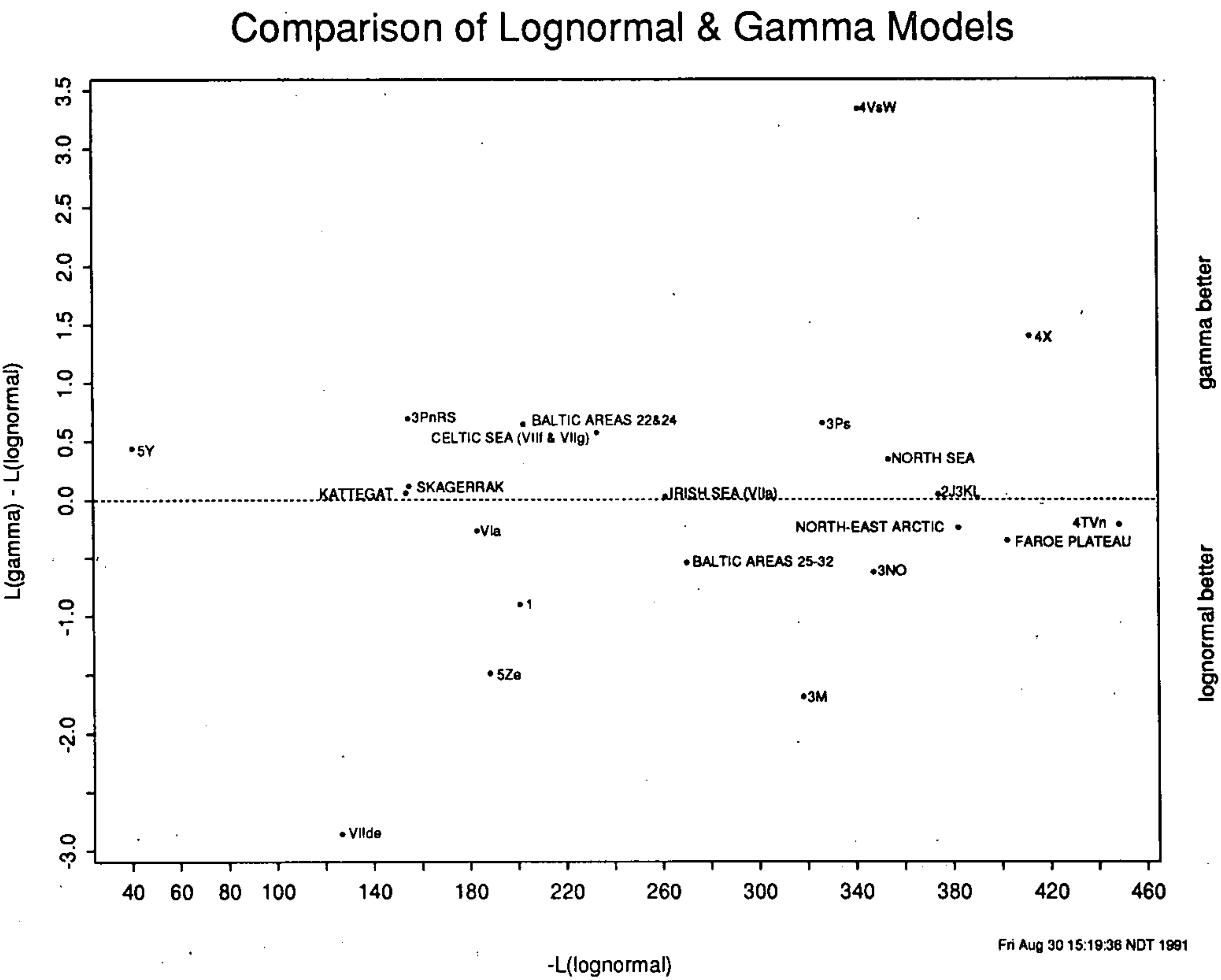

Fig. 6. Log-likelihood of the gamma distribution - log-likelihood of the lognormal distribution verses the negative of the log-likelihood of the lognormal fit for each cod stock. Stocks falling above the line are better described by the gamma model.

Table 3.10.A. Stock: COD IRISH SEA

YEAR CLASS	VPA 1 YR OLDS	N WALES GROUNDFISH SURVEY NO/16HRS 0 GR OCT	1 GR MAR	1 GR JUN	1 GR OCT	P-REC GAD SURVEY NO/12HRS 0 GR	1 GR
1975	2927	-	20	4	18	-	-
1976	4339	21	54	20	48	-	-
1977	4523	11	30	18	3	-	-
1978	9779	19	292	51	10	-	26.0
1979	11615	491	777	267	173	84.0	41.0
1980	6519	51	77	212	98	32.0	5.0
1981	2891	5	10	7	8	.0	2.0
1982	4334	113	240	31	29	7.0	7.0
1983	6391	168	155	11	11	9.0	8.0
1984	6493	36	132	53	17	1.0	1.0
1985	5361	1	6	17	5	.0	2.0
1986	18996	458	686	210	412	15.0	26.0
1987	16035	50	*	51	20	12.0	**
1988		1		7		**	

Fig. 7. Irish sea cod recruitment indices. Note that there is much greater variability in younger juvenile stages. This is not due only to measurement error.

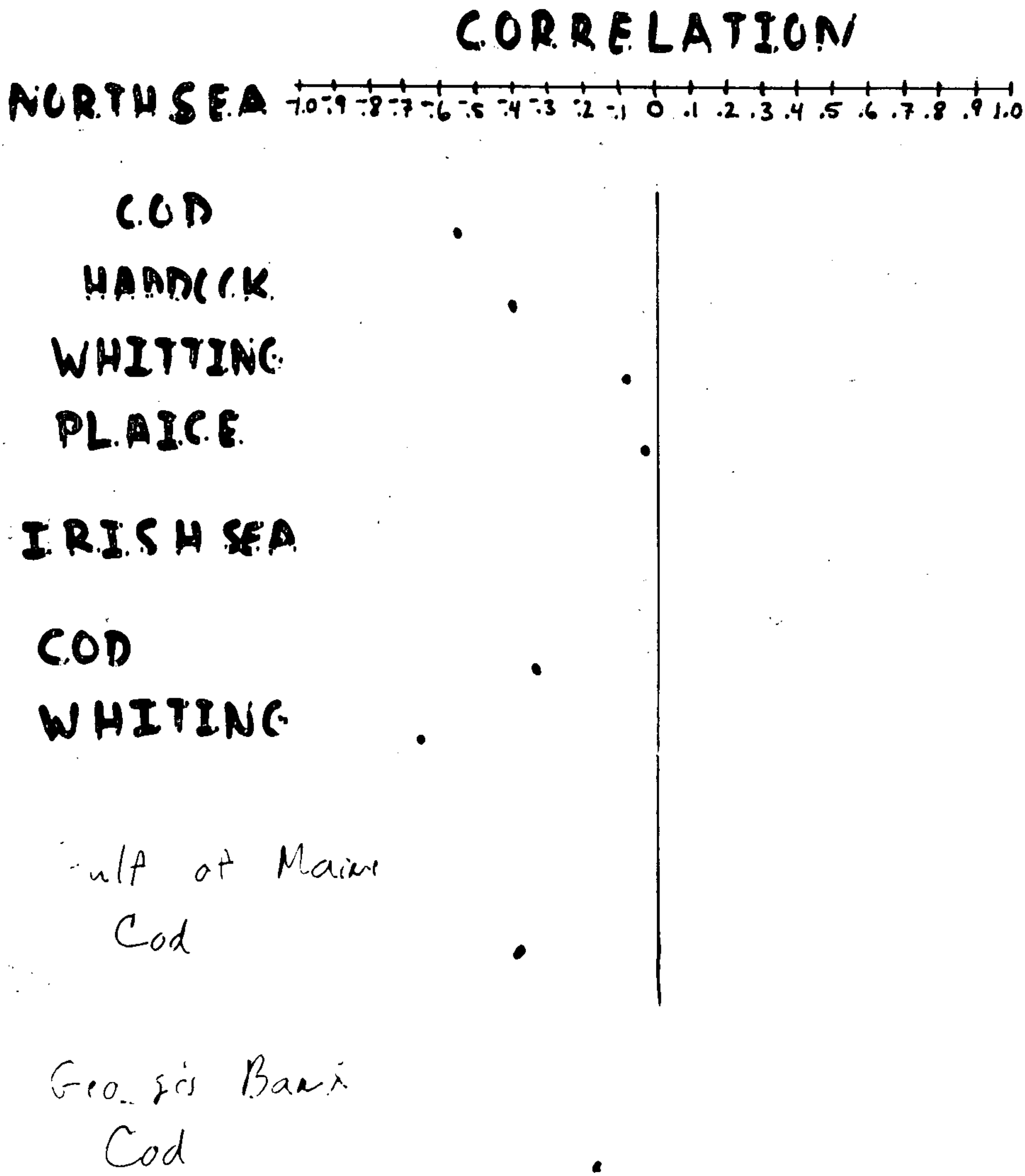

Fig. 8. The autocorrelation in recruitment estimated using a method that "removes" measurement error.

Cod

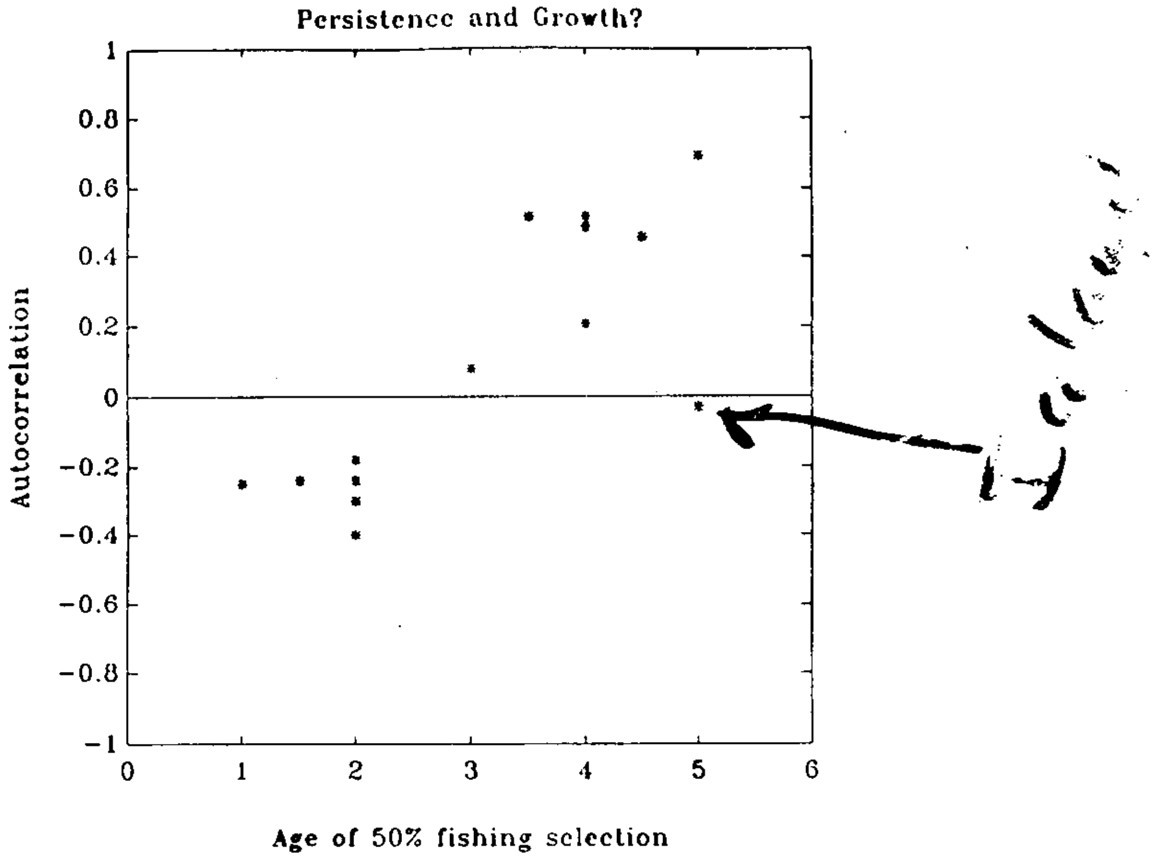

Fig. 9. Autocorrelation of VPA estimates of recruitment verses age of recruitment to the fishery.